UNIT 2 - FUELS
SECTION 1 - COMPOSITION OF FUELS

Vocabulary

alkane series	**combustion**	**hydrocarbon**	**oxygen**
butane	**covalent**	**joule**	**periodic table**
carbon	**element**	**methane**	**propane**
chemical equation	**endothermic**	**molecular formula**	**skeleton equation**
chemical reaction	**ethane**	**organic**	**structural formula**
coefficients	**exothermic**	**oxidation**	

Most fuels are **hydrocarbons**, that is, chemical compounds made up only of hydrogen and carbon. Hydrocarbons are part of the larger family of **organic** compounds. Any compound that contains a **carbon** atom is referred to as an organic compound. The reason is that carbon compounds were first identified in plants and animals, and "organic" means "related to living things." Organic compounds are plentiful. More than 90 percent of all known compounds contain carbon.

Figure 2-1-1 *Carbon is represented by the letter C in the periodic table of elements. The number 6 in the upper left corner is its atomic number. The number below it, 12.011, is its atomic weight.*

Find carbon in the **periodic table**. Carbon is found in the fourth column of the table, grouped with the other elements that have four electrons in their outer energy shell. Since atoms form chemical bonds by sharing their outer-shell electrons, a carbon atom can bond with up to four other atoms at the same time.

Structure of Molecules

A **molecular formula** indicates the number of atoms of each **element** in one molecule of a compound. The molecular formula for **methane** is CH_4. A molecule of methane has one atom of carbon (C) and four atoms of hydrogen (H_4).

The molecular formula doesn't tell how the atoms in a compound are arranged. A **structural formula** will tell you approximately how the atoms are arranged. Notice in the structural formula on the p. 130 that a dash is used to represent the pair of shared electrons that form the bond.

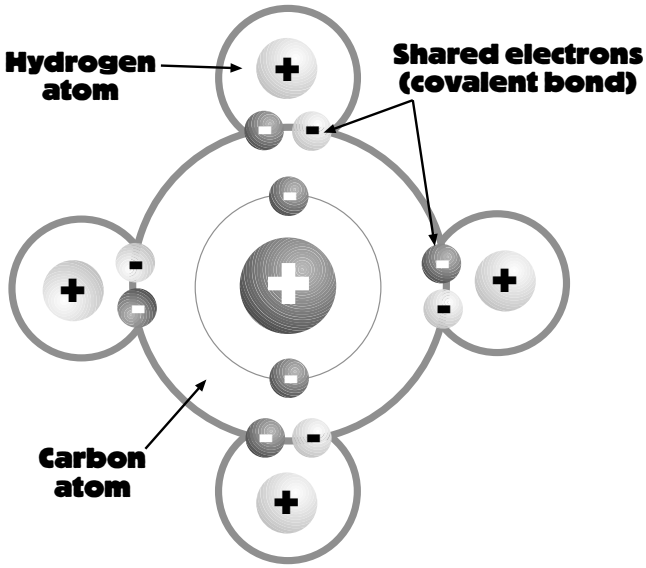

Figure 2-1-2 Graphic representation of methane molecule
The single carbon atom forms covalent bonds with four hydrogen atoms.

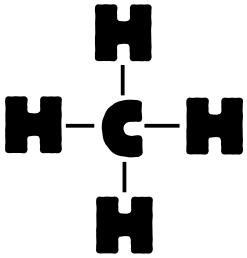

Figure 2-1-3 *Structural formula and molecular formula for methane*

Although structural formulas give you some idea of the structure of a molecule, they do not show the atoms' exact arrangement. For example, methane is a three-dimensional pyramid with four faces.

When one of methane's hydrogen atoms is replaced by a second carbon atom, the new compound is called **ethane**. The molecular formula for ethane is C_2H_6. If a third carbon atom replaces another hydrogen atom, the chemical compound formed is **propane**. Adding a fourth carbon atom to the chain forms **butane**.

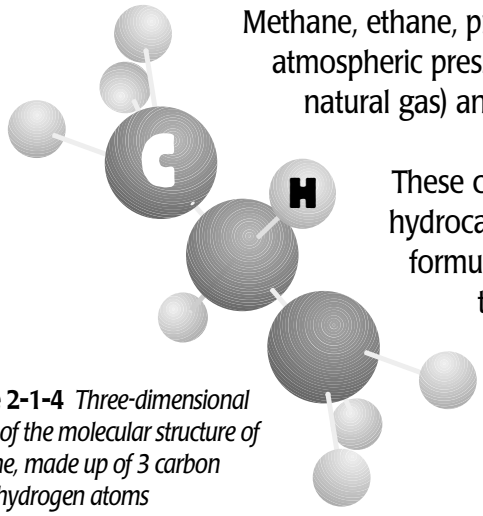

Figure 2-1-4 *Three-dimensional model of the molecular structure of propane, made up of 3 carbon and 8 hydrogen atoms*

Methane, ethane, propane and butane are all gases at room temperature and normal atmospheric pressure. All may act as fuels. Methane (the principal component of natural gas) and propane are currently used as alternative fuels for vehicles.

These compounds are members of the **alkane series**—a family of hydrocarbons having the general molecular formula C_nH_{2n+2}. In this formula, "n" stands for the number of carbon atoms. The formula states that the number of hydrogen atoms in any alkane is two times the number of carbon atoms, plus two. For example, propane has three carbon atoms. Therefore, propane has (2 x 3) + 2 hydrogen atoms. Its molecular formula is C_3H_8.

Chemical Equations

A change from one substance to another is called a chemical change or a **chemical reaction**. A **chemical equation** is a statement of a chemical change using chemical symbols. For example, when one of methane's hydrogen atoms is replaced by a second carbon atom, a chemical reaction occurs and ethane and hydrogen are formed. This reaction can be expressed as a chemical equation.

$$CH_4 + CH_4 \rightarrow C_2H_6 + H_2$$

(The arrow means yields or changes into)

Notice that an equal number of each type of atom exists on each side of the equation. This is consistent with the Law of Conservation you studied on page 61 of unit 1, section 1. Chemical equations are meaningless unless they are balanced.

Combustion

Combustion is a chemical reaction. In a chemical reaction, molecules are broken up and their atoms are rearranged to form different kinds of molecules.

All chemical reactions are either **endothermic** or **exothermic**. Use your knowledge of roots and prefixes to make an educated guess about what these words mean. First, study the root "therm." In what other words have you seen this root? What has it meant? Now, what is an exothermic reaction? An endothermic reaction?

Combustion is the term for a rapid **oxidation** process, commonly called burning. All combustion therefore requires **oxygen**, which is why a candle flame inside a closed jar goes out when it uses up all the available oxygen. Much of our energy, including most energy to power vehicles, comes from the combustion of hydrocarbon fuels, because combustion is an exothermic process.

The complete combustion of methane is represented by the molecular equation:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Hot or Cold?

When baking soda and vinegar are put together you can see and feel the chemical reaction. The baking soda bubbles, the bubbles pop and a gas is released. When you feel the container the baking soda and vinegar are in you will notice that it is cold. Which type of reaction has occurred, endothermic or exothermic?

When you put magnesium and hydrochloric acid together in a container you can see and feel the chemical reaction, too. During the reaction the metal bubbles, the bubbles pop and a gas (hydrogen) is released. When you feel the container you will notice that it is warm. Which type of reaction has occurred, endothermic or exothermic?

Composition of Fuels Resource List

http://antoine.fsu.umd.edu/chem/senese/101/compounds/index.shtml
Frostburg State University, Maryland
Resource for secondary students and teachers of introductory chemistry. Includes interactive tutorials, quizzes, databases, tools, interactive molecular models, searchable databases of glossary terms, frequently asked questions, and web site reviews.

http://newtraditions.chem.wisc.edu/FPTS/fbeqns/ChemEqnf.htm
University of Wisconsin, Madison
College-level site developed under a National Science Foundation grant to help students learn chemistry on their own. Includes lessons on balancing chemical equations, sample problems, computer exercises, environmental and combustion reactions.